Single Munition Variable Velocity Non-Lethal Ballistic System for Fires Near the Muzzle to More Than 100 Meters

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Introduction

- Blunt impact non-lethal weapons are difficult to employ across operationally useful ranges: muzzle to 100 meters.
  - They are only effective over a small interval of distance due to impact velocity and accuracy limitations.
- Multiple weapons and munitions are required.
  - complicating logistics and training.

There is a need for a single weapon/munition capable of effective non-lethal fires from the muzzle to > 100 meters.

Effective fires beyond 60 meters provides for safe standoff

A Single Weapon/Munition Must be Predictable at all Useable Ranges

- Consistent terminal effects ease decision making and use.
  - Impact velocity needs to be constant (± 5 m/sec.) across the entire range of engagement distances
  - Accuracy across the entire range of engagement distances keeps impact to the same region on the bodies of the intended targets.
- Effective integration by the user
  - Ease of use: simple operation
  - Small and lightweight

Risk of Significant Injury (RSI): Metric for Use

- RSI is used by commanders to determine if a non-lethal weapon **should** or **should not** be deployed.
- RSI is strongly influenced by **impact velocity and location**.
- Impact velocity decreases with range.
  - Reduces RSI and effectiveness.
  - Results are less predictable.
- Accuracy degrades with range increasing likelihood of undesirable effects:
  - Increased RSI from impact to the neck face or head.
  - Collateral damage (impact to bystanders).
  - Ineffective fires due to out right misses.
- RSI and effectiveness **vary** with range to the target

Pain Compliance Produces RSI

Balancing Effective Impact Velocity and RSI

- For each projectile there is a **minimum impact velocity** needed to achieve the desires level of pain compliance, varies across the body.
- For each impact location there is a **maximum impact velocity** that should not be exceeded (or there is a high probability of severe injury).
- In general the least vulnerable parts of the body are the heavy muscle groups of the legs and buttock.
- For consistency in training the aim point is center of mass.
  - **the torso the primary impact location**.
- "Safe" and effective impacts to the torso are also good against the extremities, **but impacts to face, neck, head, and groin likely produce sever injury**
- **Effective range of a weapon/munition is where:**
  - Impact velocity produce pain compliance with low risk of torso injury.
  - Accuracy is sufficient that aimed fire only impacts the torso and extremities >90% of the time.
  - Usually small 10 to 20 meters in length and **limited by accuracy decay**

Requirements for Single Weapon/Munition: Muzzle to 100 M

- Impact effects must be nearly constant (bracketed)
  - Simplifies and speeds decision process
- Impact location in torso and extremities on the intended target.
  - Proper zero of the weapon
  - Accurate ranging
  - Articulation of weapon or site for correct zero at each range
- Easy to use, fast to deploy.
  - Modular accessory for M4 with regulation of lethal and NL site
  - Fire control for all complex actions:
    - Accurate ranging (to <5m accuracy)
      - Automated control of all range related weapon settings
      - Articulation of NL weapon to compensate for range and maintain regulation with lethal site

Battelle Variable Velocity Prototype

Battelle Variable Velocity Prototype

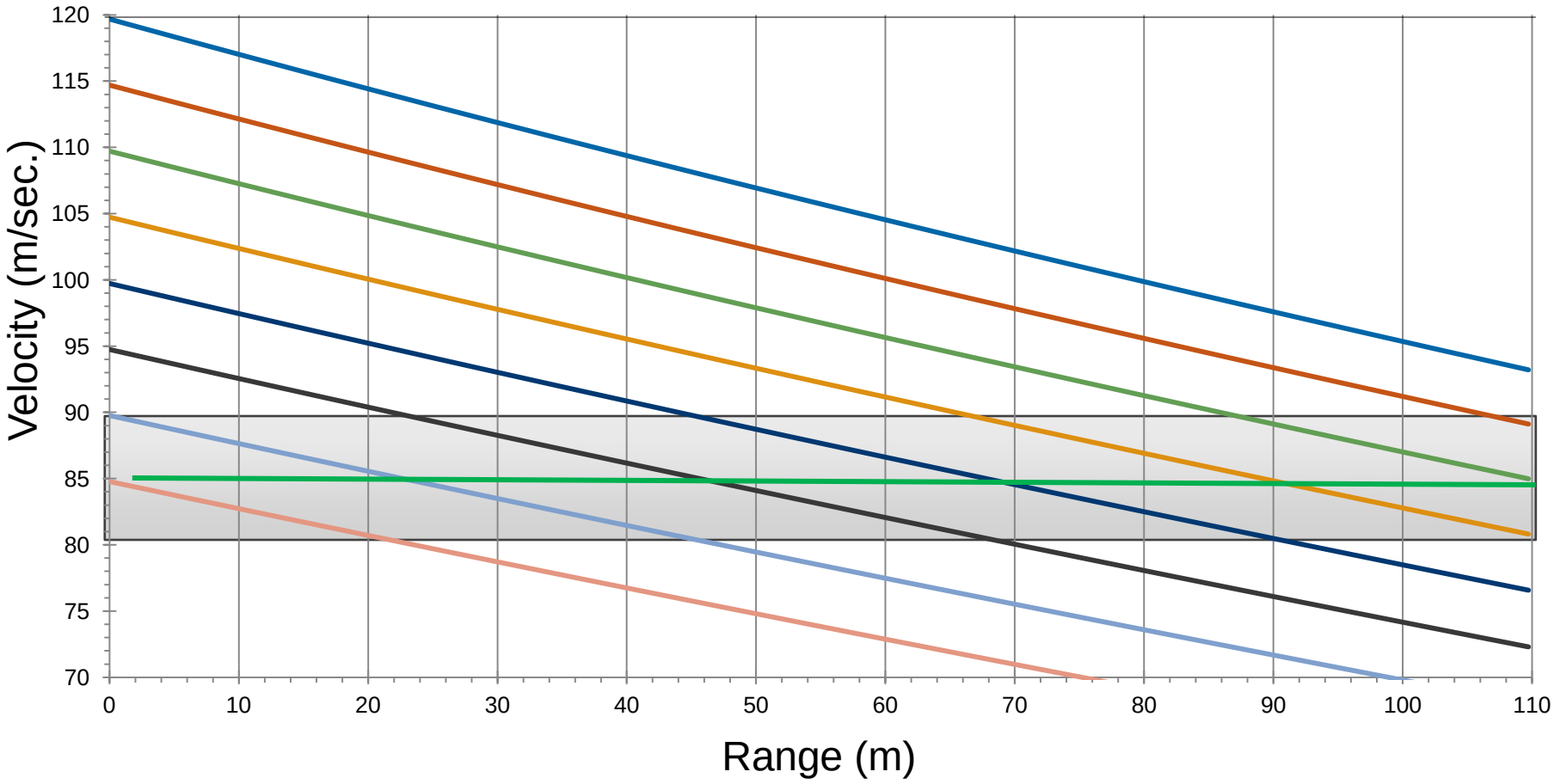
Accurate Fires

- The Weapon
  - Mechanically repeatable platform
  - Precision barrel
- The sites
  - Precise
  - Repeatable
  - Adjustable for all shooting ranges
- The Munition
  - Consistent muzzle velocity shot-to-shot
  - Aerodynamic stability over the entire trajectory
- The Shooter Skill
  - Five fundamentals of marksmanship

Doppler Radar Results

	Doppler Radar Data Measured by ARDEC ATF										
	High Velocity Mode									Low Velocity Mode	
	Raw Data			Group of 14 Shots			Group of 6 Shots			Raw Data	
	Velocity m/sec			Velocity m/sec			Velocity m/sec			Velocity m/sec.	
Shot	muzzle	30 m	100 m	muzzle	30 m	100 m	muzzle	30 m	100 m	muzzle	30 m
1	112.5	102.9	75.0	--	--	--	112.5	102.9	75.0	lost	lost
2	113.5	103.9	77.0	--	--	--	113.5	103.9	77.0	lost	lost
3	112.9	106.5	89.0	112.9	106.5	89.0	--	--	--	102.9	96.3
4	113.9	107.4	90.0	113.9	107.4	90.0	--	--	--	105.9	97.5
5	111.2	104.9	88.0	111.2	104.9	88.0	--	--	--	103.6	96.1
6	113.4	107.0	90.0	113.4	107.0	90.0	--	--	--	106.0	97.0
7	117.0	109.4	93.0	117.0	109.4	93.0	--	--	--	103.9	93.4
8	113.4	106.4	88.0	113.4	106.4	88.0	--	--	--	105.3	95.4
9	111.1	104.9	88.0	111.1	104.9	88.0	--	--	--	107.1	100.3
10	117.2	105.8	72.6	--	--	--	117.2	105.8	72.6	106.8	98.4
11	111.9	105.8	90.1	111.9	105.8	90.1	--	--	--	103.3	95.8
12	114.7	104.9	77.5	--	--	--	114.7	104.9	77.5	104.7	97.1
13	113.4	103.8	77.0	--	--	--	113.4	103.8	77.0	105.2	98.6
14	115.3	109.2	93.6	115.3	109.2	93.6	--	--	--	101.1	92.8
15	117.4	110.9	93.9	117.4	110.9	93.9	--	--	--	103.2	94.1
16	114.6	107.5	91.6	114.6	107.5	91.6	--	--	--	--	--
17	114.7	107.5	91.2	114.7	107.5	91.2	--	--	--	--	--
18	112.4	101.7	71.3	--	--	--	112.4	101.7	71.3	--	--
19	115.8	109.3	92.3	115.8	109.3	92.3	--	--	--	--	--
20	115.3	107.7	93.0	115.3	107.7	93.0	--	--	--	--	--
ave =	114.1	106.4	86.1	114.1	107.5	90.8	113.9	103.8	75.1	104.5	96.4
st dev =	1.9	2.4	7.7	2.0	1.8	2.1	1.8	1.4	2.6	1.7	2.1
extreme spread =	6.3	9.2	22.7	6.3	6.0	5.9	4.7	4.0	6.2	6.0	7.5

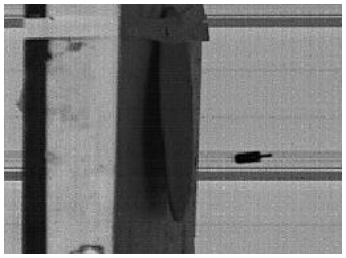
Keeping Impact Velocity Bracketed, Ideal Behavior

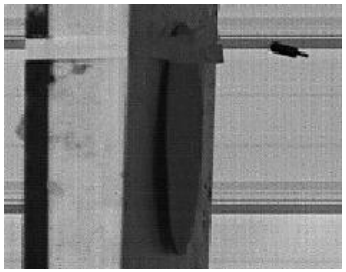


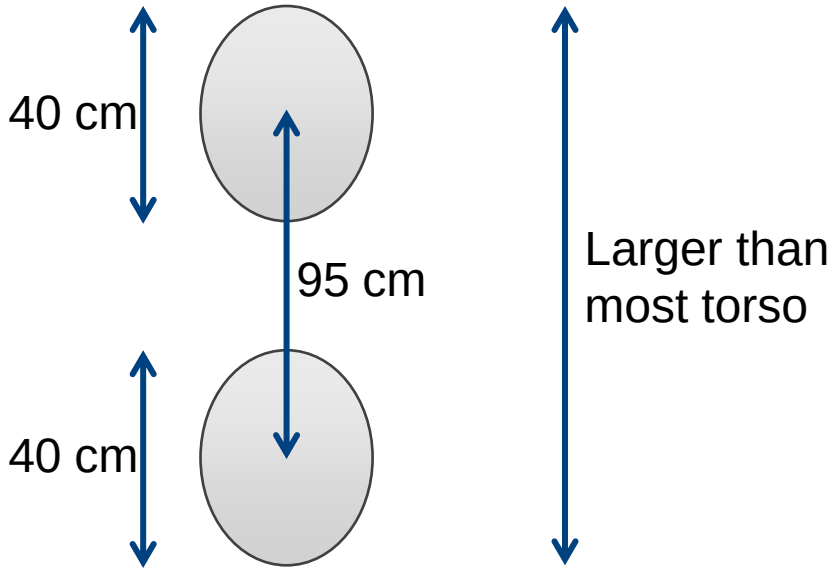
Vertical Dispersion at 100 meters

Low Yaw and High Yaw Rounds

- Extreme Spread approximately 6 m/sec.
  - Approximately ± 20 cm vertical dispersion
- Difference in average impact velocity approximately 15.5 m/sec
  - High yaw approximately 95 cm below low yaw





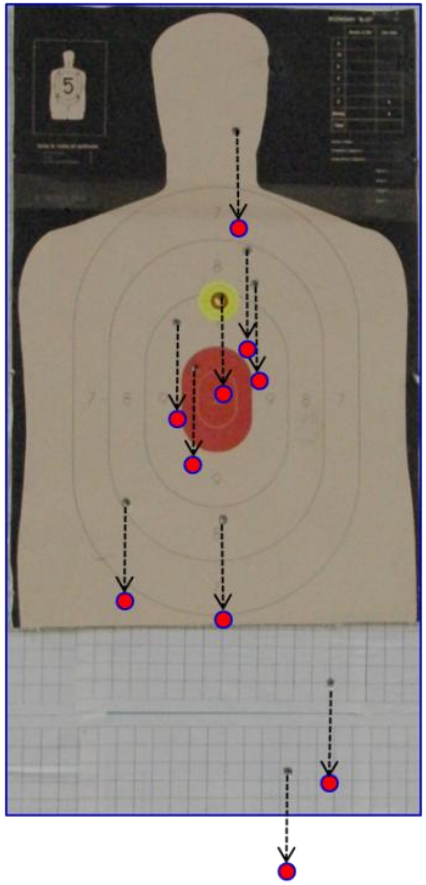


Dealing with Large Vertical Dispersion: Zeroing at Each Range

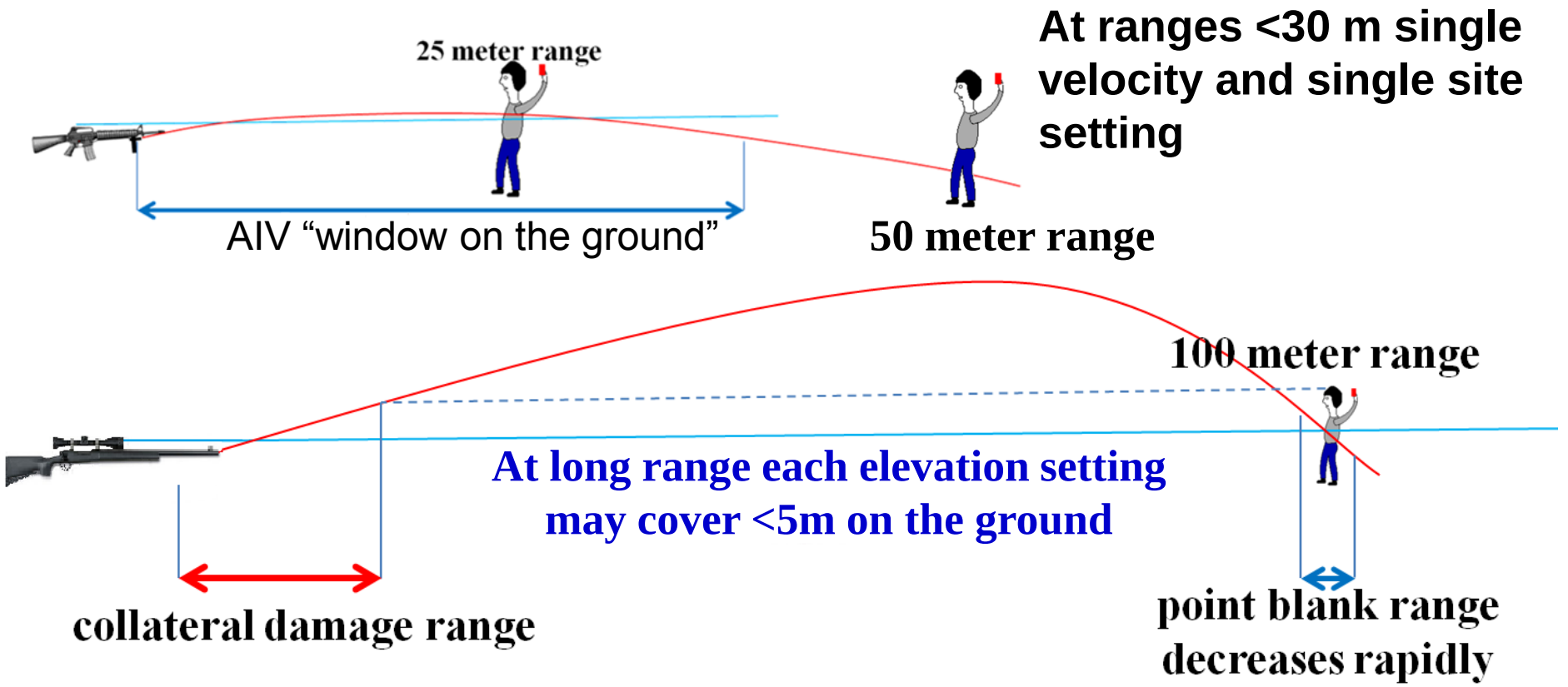
- Classic small arms zero: the geometric center of the group.
  - Works well when the group size is small.
- For large vertical dispersion placing the zero at the geometric center puts 50% of shots high.
  - Large risk of an impact to the neck, face, and head.
- For large vertical dispersion Weapon should be zeroed to the highest impact points of the group.

27 M zero to the average round

Zero at 100 M to the Most Aerodynamic Rounds



Arched Trajectory and Multiple MV



Each velocity setting may cover 20-25 meters, but at long range 2 to 4 elevation settings may be required for each velocity setting.

Multi-Muzzle Velocity Weapons Too Complex for Manual Control

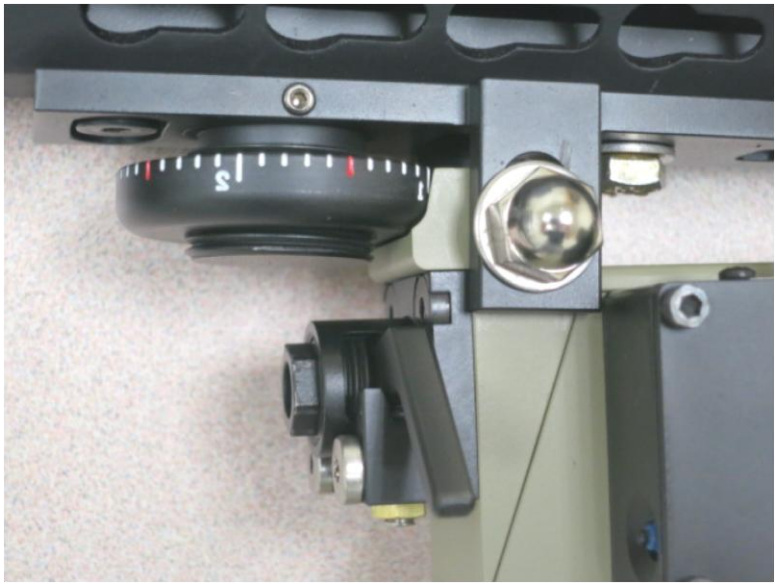
Accurate ranging, muzzle velocity selection, elevation adjustment: Too complex to do well under field conditions

- 4 to 5 muzzle velocities
- 9 to 10 elevation settings
- Ranging resolution < 5 meters
- Environmental considerations
  - Wind
  - Temperature
  - Light

} **Fire Control**

Fire Controls are not Cheap

Non-Lethal Fires are a Small Subset of Small Arms Fires
Integrating Non-Lethal and Lethal Fires in One Control Distributes Cost Over Multiple Missions



Range target, electromechanically select muzzle velocity, electromechanically adjust NL weapon elevation regulating NL Point of Aim co-incident with Lethal Point of Impact

Single Site Setting for Lethal and Non-Lethal Fires.

Next Steps

- Improve aerodynamic stability preventing bi-modal terminal velocity and very large vertical stringing
- Develop a reliable auto-loading multi-shot
- integration of commercial fire control
  - articulation of non-lethal weapon (maintain NL impact coincident with parent weapon sight)
  - automatic selection of muzzle velocity based on user input of desired effect, environmental conditions and measured range to target
- Improved manufacturability of munition

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